Operators Manual

Clarity™ Precision Frequency Reference

Laser Locked to a Molecular Absorption Line

Operating Manual WRD-20017-0

Warranty

Wavelength References warrants that this product will be free from defects in materials and workmanship for a period of one (1) year from the date of shipment. If this product proves defective during the warranty period Wavelength References, at its option, either will repair the defective product without charge for parts and labor, or will provide a replacement in exchange for the defective product.

In order to obtain service under this warranty Customer must notify Wavelength References of the defect before the expiration of the warranty period and make suitable arrangements for the performance of service. It is important that you, in advance of returning a unit, receive a Return Material Authorization Number (RMA). This will ensure the prompt handling of the repair, as well as provide important tracking information. Customer shall be responsible for the packaging and shipping the defective product to the service center designated by Wavelength References with shipping charges prepaid. Wavelength References shall pay for the return of the product to Customer if the shipment is within the United States or Canada. Customer shall be responsible for paying all shipping charges, duties, taxes, and any other charges for products returned to other locations.

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1 Introduction

This operator's manual contains useful information about the Clarity™ family of locked lasers. It contains all the information you will need to operate and maintain your laser.

If you have just received your laser, refer to section 1.3 for instructions on initial inspection. For routine operation, section 4 will be most informative.

This manual is intended to coincide with firmware version 1.00. For other firmware versions, please consult the appropriate manual or contact Wavelength References for information.

1.1 Product Overview

The Clarity is a semiconductor laser that is locked to a molecular absorption line. Lasers can be offered with wavelengths chosen from the spectra of acetylene, hydrogen cyanide, hydrogen fluoride, carbon monoxide, carbon dioxide and other gases, please inquire. The standard product configurations are available locked to a line of C12 acetylene in the 1530nm region, C13 acetylene in the 1540nm region, and hydrogen fluoride at 1312nm. Other wavelengths can be available on special order.

The laser is available as Precision Frequency Reference (PFR) and/or a Narrowed Line Laser (NLL). The PFR is designed to function as a primary frequency reference and offers an output that can be used to wavelength-calibrate optical instruments. The NLL version includes PFR functionality but additionally locks to the side of the line to provide narrowed linewidth capability.

The locking process is fully automatic and extremely robust. The fully digital architecture also allows for correction of many errors that could creep into a design based on older analog techniques.

This locking process can be considered as a primary frequency standard since the locked frequency is traceable to a physical constant. The absolute accuracy of the wavelength is limited only by the measurements (literature values or measurements made at standards bodies) made on the energy level and the small jitter inherent in the locking process.

1.2 Application

A typical application for the Clarity laser is to provide an extremely accurate and stable wavelength standard in the DWDM band. This can be used as a calibration source for an OSA (optical spectrum analyzer) or to verify operation of a wavelength meter. Most wavelength meters are actually frequency ratio meters which measure the wavelength of the unknown signal as a ratio to the built-in standard. Generally the built-in standard is a helium neon laser. These lasers are available with absolute frequency accuracy nearly as accurate as the Clarity but the wavelength at 632nm is very far from the DWDM band. Vendors of wavelength meters have developed correction algorithms to compensate for the difference of index of refraction of air and other factors that might affect the transfer of this accuracy to the DWDM band by the wavelength meter. These techniques all add a measure of uncertainty. The Clarity provides a means, heretofore unavailable, to verify the correct operation of a wavemeter up to its full capabilities with a signal in the DWDM band.

Another application of the laser is in the area of interferometric sensing. Fiber optic based hydrophones, for example, require a laser with very narrow linewidth and stable wavelength. The Clarity laser is available with a semiconductor laser with a linewidth of <30KHz. Other interferometric applications are surface roughness characterization, down-hole sensing, LIDAR wind detection, and perimeter security. For applications requiring extremely narrow kHz linewidth the Clarity platform is can be offered with extended cavity lasers from several vendors. Here we can combine the very narrow linewidth of the extended cavity laser with the long term stability of a gas line. The Clarity can be made available at several different wavelengths determined by the absorption spectra of the gases suitable for your application. Also contact factory for inquiries relating to any OEM applications as a low cost board level product is also available.

The Clarity laser is also a useful tool in gas sensing. We can provide a laser locked to many species of gases in the near IR region. This includes the greenhouse gases carbon dioxide, methane, and nitrous oxide and other species such as hydrogen fluoride, hydrogen chloride, hydrogen sulphide, carbon monoxide, acetylene, ammonia, and others. The absorption line can be scanned under software control and along with the electrical output of the gas cell the laser is an extremely useful tool in gas sensing and gas sensing system development.

1.3 Visual and Operational Inspection

The Clarity laser is packed in a carton designed to give adequate protection during shipment. If the outside of the shipping carton is damaged, notify your shipping department and carrier immediately. If the external packaging is not damaged carefully remove the contents. The contents should include:

- Clarity laser
- Power cord
- Cal certificate and manual (manual may be emailed separately)
- BNC rear interlock short

1.4 Options and Accessories

The Clarity laser is available in a number of different wavelengths; check with factory for the latest availability. The unique architecture used allows some tuning of the wavelength while still being referenced to an unchanging molecular energy level. This allows for wavelengths to be offered that are exactly on an ITU DWDM grid location (Note only available on some grid locations).The wavelength option is designated by the center wavelength. For example:

Clarity-PFR-1530

Clarity-NLL-1542

Clarity-NLL-1542-HP

Explanation:

PFR Stands for Precision Frequency Reference.
NLL Stands for narrow linewidth laser. This includes PFR functionality

1530 The laser wavelength in nm. Standard versions are:
1530nm locked to the P9 line of C12 acetylene
1542nm locked to the P16 line of C13 acetylene
1312nm locked to the P3 line of hydrogen fluoride
[other wavelengths available – consult factory]

HP High power option for the NLL, includes PM fiber output at >30mW

1.5 Operating Environment

The Clarity laser should be used in an area which satisfies the following conditions:

- Ambient Temperature: 0°C to 50°C (operating temperature)
- Relative Humidity: <85% non-condensing
- Low noise area. While the Clarity laser is designed for noise immunity the best performance will be achieved in a low EMF area. Please use a noise line filter in an area where high noise is unavoidable

2 Theory of Operation

2.1 Operating Principles

The Clarity family of locked lasers is designed to provide a source of coherent radiation in the near IR with extremely precise wavelength. A primary wavelength reference should have a higher accuracy than any application. One application would be for performance verification of wavelength meters or optical spectrum analyzers. The state of the art in this application would be wavelength meters that use a stabilized single line HeNe laser reference such as the Agilent 86122A or the Bristol Instruments 721 with an absolute accuracy of +-0.3pm. A wavelength reference with absolute accuracy on the order of 0.1 picometer would thus be sufficient for both today's and tomorrow's needs. Fundamental atomic or molecular absorptions are known to provide wavelength references of this accuracy which are very stable under changing environmental conditions such as temperature or pressure variations, or the presence of electromagnetic fields.

A search of available wavelength references turns up only a few candidates in the 1550nm band. There is only one known gas laser reference line: the helium-neon 1523nm laser line. This laser line has a much lower gain than the more common 633nm helium-neon laser line. Helium-neon lasers normally lase in multiple longitudinal modes. A multi-longitudinal laser can only practically be stable to about 1ppm due to wavelength variations in response to modal competition. Stabilized helium-neon lasers are available at 632nm where the laser is designed to operate with just two modes lasing. These modes are monitored and forced to have the same output power. In this case the wavelengths of these modes will be equidistant from the center of the gain curve and can be stabilized to 0.2ppm. This stabilized configuration is much more difficult to achieve with a helium-neon laser operating at 1523nm and has been discarded as a practical candidate for a primary wavelength standard for DWDM. The only atomic absorption lines in this region are between excited states and thus require initial excitation by a laser or electric discharge creating many practical difficulties. Another possibility investigated was frequency doubling 1500-1560nm light to probe atomic transition in the 750-780nm area. This approach requires complicated and expensive apparatus.

Molecular transitions of acetylene and hydrogen cyanide in the overtone bands can be probed directly to provide stable frequency references in the 1510nm to 1565nm region. These transitions have been widely researched and the fundamental energy levels are known to less than 1 part in 10^9 (on the order of 0.0015 picometer) in the case of acetylene. NIST (National Institute of Science and Technology) has also identified these materials as primary wavelength standards in the DWDM band and offers SRMs (Standard Reference Materials) both in acetylene (SRM2517 and 2517A) and hydrogen cyanide (SRM2519). These SRMs are simple absorption cells alone and the user must supply the illumination means. Wavelength References also offers absorption cells of similar design to the SRMs both as bare absorption cells or packaged with a broadband emitter to offer a source of absorption lines for OSA calibration.

In response to the need for a narrow band wavelength emitter with primary wavelength reference quality, Wavelength References has developed a laser that can be locked to a molecular absorption line of a variety of gas species. The laser used is a standard fiber based butterfly package laser chosen for its output wavelength characteristics. A portion of the laser output is split off and sent through a cell containing purified and isotopically selected gas. The cell absorbs the light in a very narrow wavelength range that is extremely stable and accurately known.

Two lock modes are provided: In Reference Mode the laser stabilizes to the center of the absorption line. In Line Narrowed Mode the laser stabilizes to the side of the absorption line. The two modes have different locking techniques giving somewhat different performance envelopes. Reference Mode gives an absolute reference for the average wavelength of the signal so has superior long term stability. Line Narrowed Mode has superior locking bandwidth; so high, in fact, that the laser linewidth is actually narrowed by the locking process. Though still offering great long term stability, Line Narrowed Mode lacks an absolute reference due to the dependence on the threshold lock point.

For Reference Mode the absorption signal is detected by a photodiode and digitized. The digitized data is sent to the microprocessor which uses the data to tune the laser wavelength to track the desired absorption signal. The laser wavelength is adjusted by means of a unique dual loop configuration controlling both the laser bias and chip temperature. The loop updates at 500Hz and digitally corrects for frequency fluctuations. The digital corrections to the wavelength are very small and are on the order of <0.005pm/ step.

For Line Narrowed Mode the absorption signal is held to a fixed value in a high bandwidth analog loop allowing line narrowing of the phase noise in the laser. Again a dual loop configuration which allows the laser to stay locked essentially indefinitely without interruption is used. Any errors introduced by changes in the setting of the threshold from any mechanism (such as aging) are corrected on every self scan so at least just after self scan the absolute accuracy in side lock is quite good and errors in any case are likely only 0.1 pm or so.

The combination of a commercial semiconductor laser with a stable molecular reference results in a low cost reliable and highly accurate product that you can trust.

2.2 Accuracy

The absorption lines of acetylene have been measured, at low pressure, to an accuracy of better than one part per billion for low pressure cells. A gas cell at higher pressures can experience a pressure broadening of the line as well as a pressure shift of the line center. The pressure shift of the acetylene line has been measured by NIST and was found to be approximately 0.002 ±0.0002 picometers per Torr. The cell pressure used in the Clarity laser is 6 Torr so the pressure shift is only about 0.01 picometers and the uncertainty in this value is < ±0.001pm. The stability of the lock and the temperature dependence are the primary sources of potential error in the Clarity laser.

The design of the Clarity laser system results in a very robust lock to the absorption line. Particular attention was paid to low noise circuit design. For center lock the system incorporates a bottom seeking algorithm and for side lock a threshold seeking one. A typical repeatability and stability of <0.01 picometers (<1MHz) is measured at a constant temperature. There is essentially no long term drift due to the gas line reference. The tube construction uses a low melting temperature glass that results in a true hermetic seal. The line center lock is insensitive to cell throughput and hence requires no periodic correction. For side lock the threshold can drift with varying cell throughput. The Clarity laser therefore incorporates a self scan that scans the absorption line and corrects for any drift in the cell throughput. The temperature drift of the center lock is quite small (<20 KHz/ ºC).

The short term stability (<10 second average) and repeatability are functions of noise inherent in the laser itself and the lock mode. Center lock will exhibit somewhat higher short term frequency fluctuations due to the weaker steering of the center lock algorithm but better long term stability due to the lock to a defined physical constant namely the line center. Frequency fluctuations can be specified by parameters such as phase noise or linewidth. In a sense the parameters of laser wavelength stability, phase noise and linewidth all refer to the same thing, the frequency fluctuations of the laser, but over different time scales. For a precise definition of laser linewidth the measurement time interval must be specified. For this number to match the integrated phase noise the corresponding low frequency cutoff must be specified. DFB lasers typically exhibit a 1/f frequency noise characteristic up to about 1 MHz and a white phase noise after this. Most vendors specify the linewidth of their lasers under the assumption of a lorentzian line (white phase noise). They measure the linewidth at say a 20dB point and extrapolate the linewidth to the 3dB point under the lorentzian assumption. This certainly leads to errors with lasers having significant 1/f noise. With this definition most low power communication DFB lasers have a line width of 3-5MHz while special versions can exhibit line widths of <1MHz. The Clarity NLL uses a special semiconductor laser with a linewidth of about 200KHz even without line narrowing.

The Clarity-PFR uses a dual loop configuration that locks the laser wavelength to the molecular energy level. This is done in a way that introduces no intentional laser wavelength modulation and very stable output power. This provides exceptional accuracy in the wavelength. The Clarity NLL includes this feature and offers the same long term accuracy as the PFR but also includes circuitry that uses the gas line to narrow the linewidth of the laser. This combined with a custom semiconductor laser can offer linewidth below 30KHz. This linewidth is an actual measured value and is not modeled on a lorentzian assumption. The data sheet includes typical graphs of the lineshape for the two versions of the NLL laser (the NLL and the NLL-HP).

3 Connections

The front panel connection is the fiber optic laser output. This output has a spring hinged door to shield the laser output when no fiber connection is made. The standard fiber connector is SCAPC although an adaptor for FCAPC is available. Take care to clean all fiber connections to the laser well before making connection. This will help keep the internal ferrule clean and undamaged. If the internal ferrule is dirty you can attempt to clean it using ferrule cleaning tools available from a number of vendors. It is suggested that if repeated connection to the laser is planned that a jumper be left connected to the laser and repeated connection made to the jumper and not the laser.

The rear panel has several connections. See Section 4.4 for more information:

1. Standard IEC universal power connection with integral fuse

2. BNC connector Gas Cell Output. Replicates the gas cell output used internally for the line locking.

3. BNC connector Laser Interlock. Needs to be shorted for the laser to be enabled.

4. RS-232 Interface.

4 Operating Instructions

4.1 Getting Started

4.1.1 Password

The Clarity ships with a factory-set password of 1234. Each time the instrument is turned on, the user is asked to enter a password. Press the directional buttons (▲ and ▼) to reach 1234, then press NEXT (press and hold the buttons to quickly scroll to the desired password). The instrument is now ready to be used. To change the password, press MENU to enter the menu sub-commands then press NEXT repeatedly until the front panel displays "CHANGE PASSWORD=NO". Press either directional button to change setting to YES then press NEXT. Scroll to the desired new password using the directional buttons, then press NEXT. Press MENU to exit. The new password has been stored (note, pressing MENU to exit before pressing NEXT aborts the command).

4.1.2 Initial Calibration

Our high power (>30mW) lasers include a warm up cycle when first turned on. After the laser is first turned and the ACTIVE button is pressed, the front panel displays "WARMING UP…" for 60 seconds. The laser then enters a calibration routine and locks in the desired mode.

4.1.3 Interlock

The Clarity ships with a BNC short on the Remote Interlock input located on the rear panel. If the connection at the Interlock port is opened the laser will automatically disable. If the BNC short is replaced with an interlock circuit (for example, a door sensor), ensure the circuit is closed prior to laser operation.

4.2 Front Panel Operation

Figure 1 below illustrates the front panel buttons used to operate the Clarity.

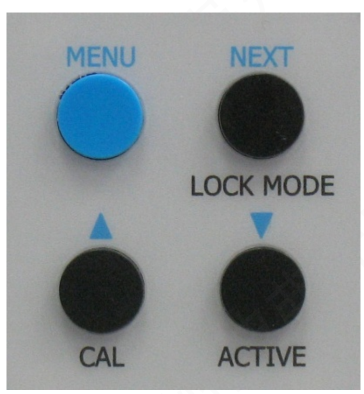

Fig. 1: Front panel button display

4.2.1 Menu

Pressing the blue MENU button gives the user access to the four settings listed below. Button behavior while in Menu mode is noted in blue above each button. Pressing NEXT cycles through the four settings, while the directional buttons (▲ and ▼) change the options within each setting. Pressing MENU a second time returns the user to the original front panel display.

1. Periodic Calibration: Sets the time between automatic re-calibrations. Options are 5, 15, 60 minutes or OFF. Note that times are nominal and that the actual time between calibrations may be slightly longer. Press MENU to return to the main display or NEXT to continue to the next setting.

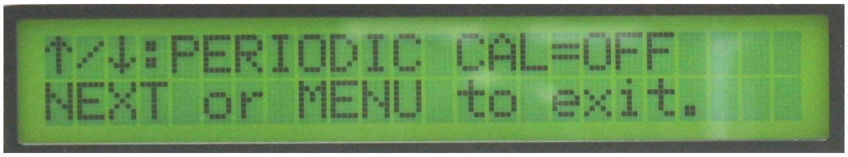

Fig. 3

2. Secure Laser: Disables laser output and prevents any changes to user settings. Select Yes by pressing one of the directional buttons, then press NEXT. The front panel will display "Laser Password" and the laser will be off. To re-enable the laser, press and hold either directional button to scroll to the correct password and then press NEXT. Press ACTIVE to turn the laser on again. Note that the laser will go through a calibration routine prior to locking.

Fig. 4

3. Change Password: Allows user to change password. Select Yes by pressing one of the directional buttons. Password display defaults to 5000. Scroll to the desired new password by pressing and holding the directional buttons. Press NEXT to store the new password. Pressing MENU instead of NEXT at this point will abort the Change Password command and return the Clarity to the state it was in when the menu was entered. Other commands selected while in Menu mode will be executed.

Fig. 5

4.2.2 LOCK MODE

The Clarity has two possible lock modes: Center and Side. Center refers to the peak (center) absorption wavelength for the gas line referenced by the particular Clarity model (for example, the PFR-1530 locks to the acetylene P9 line at 1530.37095 nm or 195.895288 THz). This is used in Reference Mode. Side refers to the left side of the peak absorption wavelength. In the case of the NLL this mode is the Line Narrowed Mode which the linewidth of the laser is further improved. The front panel Lock Mode display reports the lock mode by illuminating one of the LEDs (Fig. 6). The front panel display screen updates to the correct wavelength and frequency for each mode. Note that changing between modes induces a self-calibration.

Fig. 6: Sample Lock Mode display reporting Center Lock (Reference Mode)

4.2.3 CAL

Pressing CAL forces a re-calibration of the instrument. During calibration the instrument sweeps the laser across a limited spectral range (approx. 150 GHz) and identifies the position of the gas line's peak absorption. This information is used in the instrument's locking routines. Should you press CAL accidentally or wish to abort, press any button. If the laser is enabled, the instrument will attempt to re-lock using the original calibration data. Note that the CAL button is available only when the laser is active.

4.2.4 ACTIVE

Pressing ACTIVE toggles the state of the laser output. If the laser is initially on, the laser will turn off, "Off" will appear* on the front panel display, and the ACTIVE LED (below the laser output) will turn off. If the laser is initially off, the laser will turn on, warm up and run through a calibration routine, and then lock in the desired mode and with the desired settings. Once the laser is active, then the user can press the CAL button to recalibrate the instrument if desired.

* Older versions may display “disabled” or “inactive”.

4.3 Front panel display

After turning the instrument on and entering the user password, the Clarity PFR front panel display appears as shown in figure 7.

Fig. 7: Front Panel Standard Display

4.3.1 Frequency and Wavelength

Displays the locking frequency and wavelength of the laser output. Displayed data updates whenever the user changes either the lock mode.

4.3.2 Laser Status

Statuses are "Off", "Locking" and "Locked"*. "Off" is shown whenever the laser is turned off, either by the user or automatically by the instrument. "Locking" reports that the laser is actively searching for the target wavelength. "Locked" reports that the laser output matches that of the displayed frequency and wavelength.

* older versions may display “disabled” or “inactive”

4.3.3 Instrument Status:

Instrument Status reports warnings and errors associated with instrument operation. The field can be blank, implying there are no errors to report. Instrument Statuses are listed below:

1. "Interlock": The interlock circuit attached to the rear panel BNC output is open. The laser automatically disables. Closing the interlock circuit removes the display and allows the user to re-enable the laser.

2. "Warning": Appears after the instrument unexpectedly re-calibrates while the laser is enabled. This occurs under two conditions: 1) the interlock circuit was opened then closed, 2) the instrument's locking routine exceeded its dynamic range and had to re-center to the absorption line. This can occur if the instrument's temperature changes suddenly. To clear the Warning status, simply enter and exit out of Menu Mode by pressing MENU twice.

3. "Cal Error": Occurs when a calibration's results are out of spec with respect to the factory settings. Laser will automatically disable. Allow instrument to reach room temperature and re-calibrate. Status will clear after a successful calibration. If problem persists, contact Wavelength References.

4. "Temp Error": Occurs when the microprocessor's temperature is out of spec. The laser will automatically shut down. Allow the instrument to reach room temperature and then re-calibrate. Status will clear after a successful calibration. If problem persists, contact Wavelength References.

5. "Bad Data": Occurs when the factory settings have been corrupted. Laser will automatically disable. Try power-cycling the instrument. If problem persists, contact Wavelength References.

4.4 Rear Panel

The rear panel consists of the power-plug input, power switch, Remote Interlock BNC output, Gas Cell BNC output and an RS-232 output (see figure 8). The Remote Interlock, Gas Cell and RS-232 outputs are explained below.

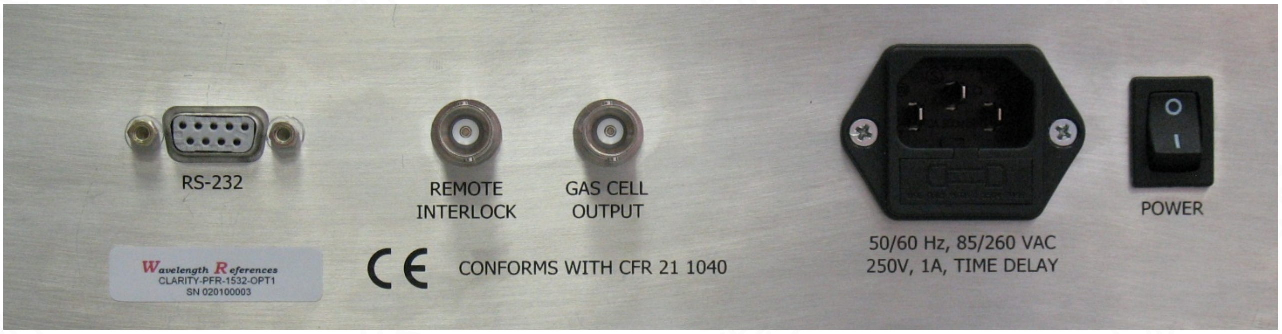

Fig. 8

1. Remote Interlock: The Clarity ships with a BNC short on the Remote Interlock input located on the rear panel. If the connection at the Interlock port is opened the laser will automatically disable. If the BNC short is replaced with an interlock circuit (for example, a door sensor), ensure the circuit is closed prior to laser operation.

2. Gas Cell Output: The Gas Cell output reports the gas cell response of the reference beam that is used to lock the laser to the target frequency. Source impedance is 50 ohms, and the output range, when driving an open circuit, will roughly fall between 0.25 V to 2.25 V when scanning the absorption line. Peak absorption (Center Lock) results in a minimal output voltage while no absorption results in maximal output voltage. This output can be used as a diagnostic or in gas sensing system experiments where the laser is scanning the line to provide an indication of the exact timing and scanning of the absorption feature.

3. RS-232: The Clarity ships with a SCPI-like command set to allow full operation of the instrument through the RS-232 port. Baud rate is initially set to 9600, the transmitter terminator to CRLF and the flow control to Xon/Xoff. See Section 5 for a list of commands.

4.5 Troubleshooting

The Clarity should be relatively trouble free. The laser used is somewhat sensitive to back reflections. The best performance will be delivered if the return loss of the connection is >30dB. Excessive back reflection will be evidenced by a roughly 0.04 picometer random fluctuation of the wavelength which may be difficult to see. The output power will also exhibit minor fluctuations in this condition.

Keep the optical connector clean. Use swabs designed for cleaning optical connectors if the connector becomes soiled.

5 External Interface

External interface to the Clarity laser is provided by means of the RS-232 connector. To use, connect the instrument through a suitable RS-232 session, such as HyperTerminal in Windows. Baud rate is initially set to 9600, the transmitter terminator to CRLF and the flow control to Xon/Xoff. The command set is listed below. Bracketed commands are optional; thus CAL:INT and CAL both perform a calibration scan. A command can be entered either in its short form (capital letters only) or in its long form (full word):

5.1 RS232 Commands and Responses

<table>
<tr><th>Command</th><th>Parameter Form</th><th>Notes</th></tr>
<tr><td>Calibration Subsystem</td><td></td><td></td></tr>
<tr><td>CALibration:[INTernal]</td><td></td><td>Performs calibration scan</td></tr>
<tr><td>CALibration:PERiodic</td><td><OFF|5|15|60></td><td>Sets periodic calibration rate</td></tr>
<tr><td>CALibration:PERiodic?</td><td></td><td>Queries periodic calibration rate</td></tr>
<tr><td>Source Subsystem</td><td></td><td></td></tr>
<tr><td>[SOURce:]FREQuency?</td><td></td><td>[xxx.xxxxxxTHz] - Queries target frequency</td></tr>
<tr><td>[SOURce:]FREQuency:MODE</td><td><LEFT|CENTer></td><td>Sets locking mode</td></tr>
<tr><td>[SOURce:]STATe</td><td><Boolean></td><td>[0|1|off|on] - Sets laser off/on state</td></tr>
<tr><td>[SOURce:]STATe?</td><td></td><td>Queries laser state (off/on)</td></tr>
<tr><td>[SOURce]WAVElength?</td><td></td><td>[xxxx.xxxxxnm] - Queries target wavelength</td></tr>
<tr><td>System Subsystem</td><td></td><td></td></tr>
<tr><td>SYSTem:ERRor[:NEXT]?</td><td></td><td>Queries error from queue (FIFO)</td></tr>
<tr><td>[SYSTem:]HEADer</td><td><Boolean></td><td>[0|1|off|on] – Selects whether header strings in query response are shown</td></tr>
<tr><td>[SYSTem:]HEADer?</td><td></td><td>Queries header string state</td></tr>
<tr><td>[SYSTem:]INTerlock?</td><td></td><td>Queries interlock state</td></tr>
<tr><td>SYSTem:KLOCk</td><td><Boolean></td><td>[0|1|off|on] - Sets front-panel locked/unlocked (Remote/Local)</td></tr>
<tr><td>SYSTem:KLOCk?</td><td></td><td>Queries front panel lock state</td></tr>
<tr><td>SYSTem:PASSword</td><td>(#####)</td><td>Enables laser system via current password. Include parenthesis when entering.</td></tr>
<tr><td>SYSTem:PASSword</td><td>(#####:#####)</td><td>Sets new password (OLD:NEW)</td></tr>
<tr><td>SYSTem:SECure</td><td></td><td>Secures laser off</td></tr>
<tr><td>SYSTem:SECure?</td><td></td><td>Queries laser secure state</td></tr>
<tr><td>SYSTem:SERial:BAUD</td><td><9600|19200|38400|57600 |115200></td><td>Sets baud rate</td></tr>
<tr><td>SYSTem:SERial:BAUD?</td><td></td><td>Queries baud rate</td></tr>
<tr><td>SYSTem:SERial:TERMinator</td><td><CRLF|LF|LFCR|CR></td><td>Sets serial transmit termination character</td></tr>
<tr><td>SYSTem:SERial:TERMinator?</td><td></td><td>Queries termination character</td></tr>
<tr><td>SYSTem:STATus?</td><td><0|1|2|3></td><td>Queries locking routing (off, calibrating, locking, locked)</td></tr>
<tr><td>[SYSTem:]VERBose</td><td><Boolean></td><td>[0|1|off|on]- Sets verbose mode to off/on</td></tr>
</table>

[SYSTem:]VERBose?		Queries verbose state
IEEE 488.2 Requirements		
*CLS		Clear status command
*ESE	<numeric value>	Standard event status register
*ESE?		
*IDN?		Identification query
*OPC		Operation complete enable
*OPC?		
*RST		Reset command
*STB?		Read status byte query
*WAI		Wait for calibration to complete

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5.2 Error and Event Codes

The eight most recent error and event codes are stored in an array and can be queried with the command "SYSTem:ERRor:[NEXt]?". Query repeatedly to produce the full array.

Error Code Definitions:

//No event messages	
"0, "No error"	// No error
"1, "Empty input buffer"	// No input command to parse
"2, "Too many numeric suffixes"	// Too many numeric suffices in Command Spec
//Command error messages	
"-100, "Command error"	// Command error message
"-103, "Invalid separator"	// Unmatched bracket
"-104, "Data type error"	// Wrong type of parameter(s)
"-108, "Parameter not allowed"	// Invalid number of dimensions in a channel list
"-110, "Command header error"	// Command keywords were not recognized
"-115, "Unexpected number of parameters"	// Wrong number of parameters
"-120, "Numeric data error"	// Invalid value in numeric or channel list, e.g. out of range
"-131, "Invalid suffix"	// Numeric suffix is invalid value
"-150, "String data error"	// Unmatched quotation mark (single/double) in parameters
//Execution error messages	
"-200, "Execution error"	// Execution error message
"-203, "Command protected"	// Command password protected
"-220, "Parameter error"	// No entry in list to retrieve (number list or channel list)
"-221, "Settings conflict;Check rear interlock"	// Settings Conflict - Check rear interlock
"-222, "Data out of range"	// Data out-of-range
"-223, "Too much data"	// Parameter of type Numeric Value overflowed its storage
"-224, "Illegal parameter value"	// Too many dimensions in entry to be returned in parameters
"-240, "Hardware error;Temperature"	// Temperature error
"-241, "Hardware missing;Rear interlock opened"	// Warning - Rear interlock opened
"-294, "Incompatiable type"	// Wrong units for parameter
//Device-specific error messages	
"-300, "Device-specific error"	// Device-specific error message
"-310, "System error;Invalid password"	// System Error - Invalid password
"-313, "Calibration memory lost"	// Non-volatile calibration data corrupted
"-315, "Configuration memory lost"	// Non-volatile configuration data corrupted
"-340, "Calibration failed"	// Internal calibration error
"-350, "Queue overflow"	// Queue overflow error
//Query error messages	
"-400, "Query error"	// Query error message
//Power-on event	
"-500, "Power on"	// Power-on event message
//User-request event	
"-600, "User request"	// User request event message
//Request control event	
"-700, "Request control"	// Request control event message
//Operation complete event	
"-800, "Operation complete"	// Operation complete event message

6 Specifications

6.1 Table of Specifications

Specification	Performance	Notes
Wavelengths available	1530nm 1542nm 1312nm 1653nm Other wavelengths	Standard for PFR, NLL-HP Standard for all options Standard for PFR Standard for PFR, methane sensing Inquire
Lock wavelength modes	Reference Lock Line Narrowing	Locks to the center of the absorption line. Locks laser to the slope of the absorption line
Wavelength Absolute Accuracy	<±0.0001nm <±0.00002nm	At 25°C ± 5°C after self calibration Typical The Clarity is a primary frequency standard locked to a physical constant. We rely on published wavelength data from HITRAN or NIST where available.
Wavelength Reproducibility	<±2 MHz <600Khz RMS	Typical At 25°C ± 5°C after self calibration
Side mode suppression	>35 dB	Typical
Laser Linewidth (Line Narrowing Lock)	<30Khz <150KHz <1MHz <5MHz	NLL NLL-HP PFR-HP PFR
Laser Linewidth (Reference Lock)	<200KHz <1MHz <1MHz <5MHz	NLL NLL-HP PFR-HP PFR
Output power	5mW >30mW	Typical HP versions
Output power stability	±0.01dB	Typical over 24 hour ±5 ºC
Fiber Type	SMF 28e PM Panda	Typical HP versions
Fiber Interface	SCAPC	FCAPC Jumpers available
External Interface	RS232	
Operating temperature range	0°C to +50°C	
Power Requirements	90-250VAC, 50/60Hz	
Fuse	1.0 Amp time delay	

7 Safety and Regulatory Compliance

The laser used in the Clarity is by itself a Class IIIB device.

The power supply used in the product completely complies with EN60950 1992 +A1, +A2:1993, +A3:1995, as well as LVD 73/23/EEC

The standard acetylene cell contains about 50 micrograms of acetylene at about 0.03 atmospheres pressure. The only hazard from non-pressurized acetylene would be due to its flammable nature. If the gas tube broke the contents would immediately mix with the air in the rest of the cell housing. The resultant mixture would contain an acetylene concentration of 0.08% acetylene. This is considerably less than the minimum of 2.7% necessary for the mixture to be flammable. The hydrogen cyanide cell contains <100 micrograms of HCN and hence would pose no toxic hazard under any conditions.

The conclusion is that, as packaged, the cells do not contain a flammable or hazardous gas and hence do not need a special transportation classification, may be shipped by any customary means.

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